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THE LOAD IMPLICATIONS OF NEAR-NET-SHAPE CASTING OF STEEL

Report No 91-42-K

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ABSTRACT

This study was carried out to determine the implications of a Near-Net-Shape Casting technology for steel strip on the electrical demand of the steel industry. The study was based on the literature, consultant's knowledge and information from direct industrial contacts. The load implications of this new technology will be quite significant depending on which sector of the steel industry adopts it. If integrated companies replace a major portion of their ingot production over the next 20 years with near-net-shape casting then the power requirements would be lowered by 34 MW. However, this technology may allow electric arc furnace operators to enter the flat-rolled market which would increase the power demand by 13.8 - 24.2 MW depending on the level of penetration. The technical feasibility of this technology will likely be determined in the next 3-5 years. The effort in Canada is being handled by "Projet Bessemer", a consortium of Canadian steel companies.

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81-377-111	808.274	March 5, 1991	91-42-K

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EXECUTIVE SUMMARY

THE LOAD IMPLICATIONS OF NEAR-NET-SHAPE CASTING OF STEEL

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Metallurgical Research Department

Ontario Hydro Research Division was contracted to ascertain the load implications of Near-Net-Shape Casting of strip steel upon the steel industry. The study was based upon the literature, consultant's knowledge and information gained by direct contact with the companies and with "Projet Bessemer".

Several companies have sponsored a company in Canada, "Projet Bessemer", whose sole purpose is to choose or develop a near-net-shape casting technology to replace ingot casting and slab casting. The operating and investment cost incentives for such a new technology are very attractive.

The load implications of this new technology may be quite significant. At this stage of technology development load estimates can only be highly speculative but may suggest possible trends. Should the integrated companies replace a major portion of their ingot production (3,000,000 tonnes) with near-net-shape casting over the next 20 years then the power requirements would be lowered by 34 MW. On the other hand should the non-integrated (electric furnace) companies enter the flat rolled market because of the lower investment and potentially smaller economic plant size, then power requirements would increase. For example if these non-integrated companies (mini-mills) produced 700,000 tonnes/year by near-net-shaped casting over the next 20 years they would require 53.8 MW versus 29.6 MW if it were produced in the integrated companies, a net increase of 24.2 MW. The near-net-shape casting of steel may allow mini-mills to compete in the flat rolled domain of the integrated companies but with a load penalty of 24.2 MW. A more likely scenario may be 400,000 tonnes/year resulting in a smaller load penalty of 13.8 MW. Many other scenarios may be possible with near-net-shape casting, some of which are enlarged upon in the text.

The technical feasibility of this new technology will in all likelihood be determined within the next 3-5 years. Should it be successful, the steel companies will become more competitive in the world picture. The electrical load implication will probably be of the magnitude of speculations in the following report.

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81-377-111	808.274	March 5, 1991	91-42-K

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To Dr. N. Burnett
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THE LOAD IMPLICATIONS OF NEAR-NET-SHAPED CASTING OF STEEL

R.A. Reesor and F.J. Pearce

1.0 Introduction

The Canadian Steel Industry maintains its determination to remain competitive internationally and also with other materials. A number of companies have joined together to form "Projet Bessemer" a company whose sole purpose is to choose the technology it is hoped, will allow them to Near-Net-Shape Cast strip steel products of steel.

NNSC* of strip, if technically successful, will potentially lower the investment and operating costs of the flat rolled steel business. NNSC, in essence, would replace ingot casting and possibly slab casting of steel and eliminate the hot strip mill, a major investment item of the integrated companies.

NNSC may also provide an opportunity for non-integrated (electric arc furnaces) companies in Ontario to enter the flat rolled field because of the lower investment costs and the smaller size of an economic NNSC facility. It has been proposed by 'Projet Bessemer'/1/ that an economic plant could produce 250-300,000 tonnes/year of NNSC product, a very much smaller increment than the 2,000,000 tonne/year facility of the integrated plant.

The following text is a speculation of the potential power implications of NNSC on the steel industry. The main driving force will be the economic factors in favour of NNSC rather than the power requirements.

---

* NNSC - Near-Net-Shape Casting

2.0 Description of Steel Casting Processes

In the past and to a considerable degree at present, molten steel for flat rolled products was cast in large blocks called ingots by the integrated steel industry. In recent times this process has been gradually abandoned in favour of continuous casting of slabs in a strand casting machine. The result has been improved economy, yield and product quality. The next round of improvement may come from the adoption of a new continuous casting process which aims at casting flat rolled steel products at a thickness near the final thickness of the desired product ie Near-Net-Shape Casting. This technology is under development all over the world. Two themes are being pursued, one which aims at casting thinner slabs and the other which aims at casting of even thinner material called strip. Figure 1 shows the process steps required for all of these approaches. It becomes very evident that many costly steps can be eliminated the further a company moves towards NNSC.

The incentives for the development of NNSC are primarily economic and are as follows:

- Capital cost is estimated to be half of that for a slab casting of hot strip mill complex depending on the casting rate obtained.

- Operating costs may be reduced by $45.00 a tonne of strip produced, which may vary somewhat depending on plant scale, casting thickness and speed.

- The economic plant size can be decreased to 200,000 tonnes/year versus the present slab casting plant size of 2,000,000 tonnes/year thus allowing the small non-integrated plants to enter the flat rolled business.

Another very important element in continuous casting is the improvement of product yield. The replacement of ingot casting by continuous casting has resulted in about a 10-14% yield improvement. The movement to NNSC could improve this further by another 2 or 3%.

The switch to NNSC of strip from ingot production will have a large electrical load implication. From Figure 1 it maybe seen that there are a number of steps eliminated, most of which are large electricity consumers.

There are a number of concepts being developed for the continuous casting of strip. They consist of casting steel between two water cooled rolls, on a single roll, between two moving belts, etc. Some of the approaches are presented in Figure 2.

FIGURE 1 - PROCESS STEPS IN THE CASTING OF STEEL

INGOT CASTING	CONVENTIONAL CONTINUOUS SLAB CASTING	THIN SLAB CASTING	NEAR-NET-SHAPE CASTING OF STRIP (NNSC)
Steelmaking	Steelmaking	Steelmaking	Steelmaking
↓	↓	↓	↓
Ingot Casting			
↓	↓	↓	↓
Ingot Soaking			
↓			
Slabbing	Slab Casting		
↓	↓	↓	↓
Slab Conditioning	Slab Conditioning		
↓	↓		
Reheating	Reheating		
↓	↓	↓	↓
Roughing	Roughing	Thin Slab Casting	
↓	↓	↓	
Hot Finishing	Hot Finishing	Hot Finishing	Twin Roll Strip Casting
↓	↓	↓	↓
Acid Pickling	Acid Pickling	Acid Pickling	Acid Pickling
↓	↓	↓	↓
Cold Rolling	Cold Rolling	Cold Rolling	Cold Rolling

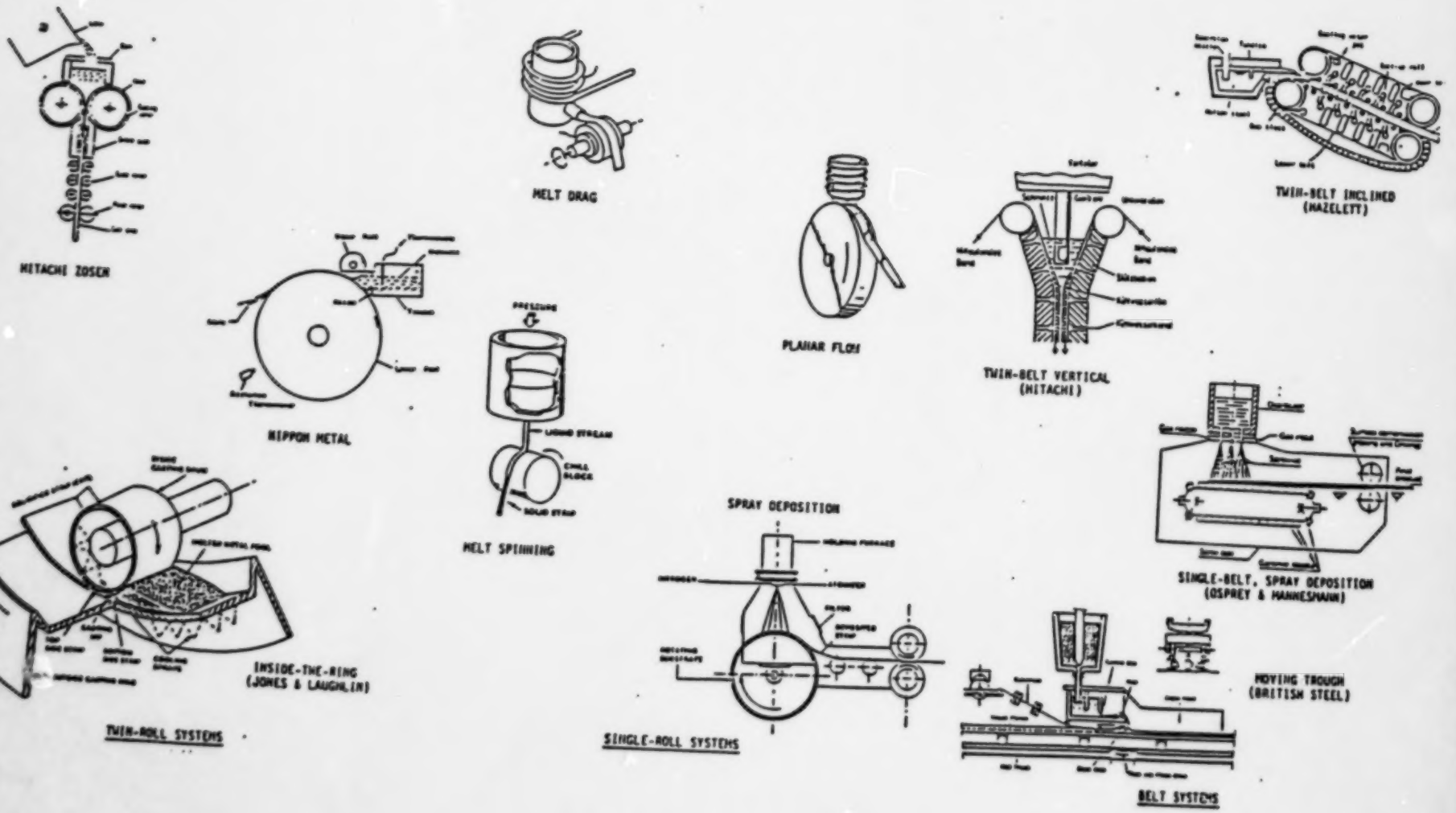

FIGURE 2 - NNSC TECHNIQUES

Projet Bessemer plans to carry out research using the twin roll caster concept. A pilot plant version of their approach is shown in Figure 3.

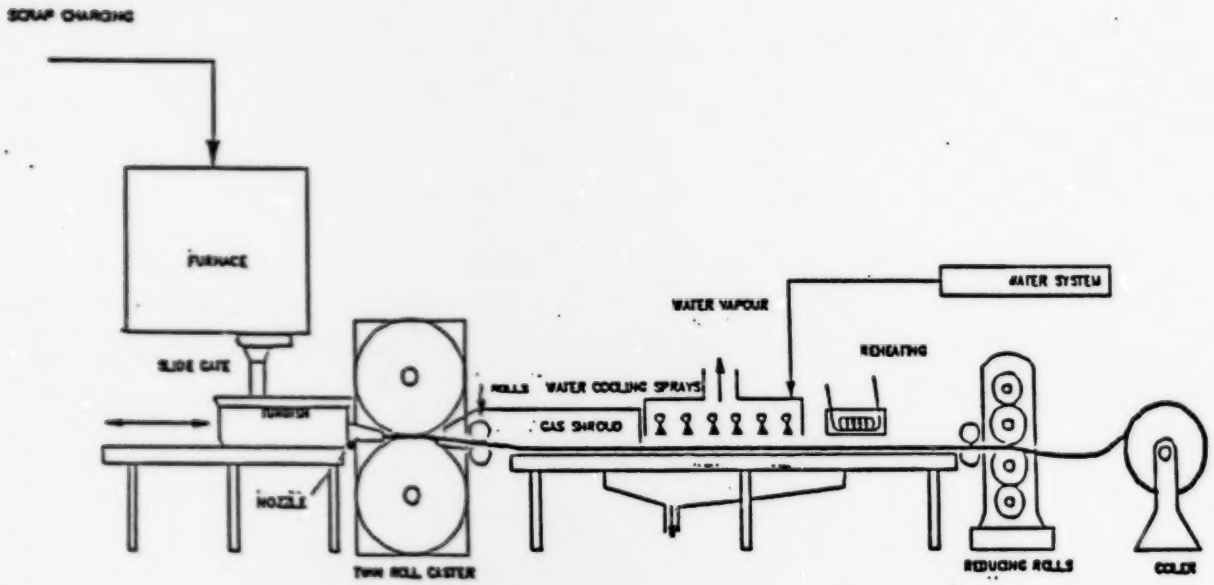

FIGURE 3 - TWIN ROLL CASTER CONCEPT

The actual form of Projet Bessemer's casting process may vary significantly from that shown in Figure 3. A number of development teams are currently dealing with the many technological aspects of the process. Their findings will be evolved and incorporated into a final flow sheet which will remain confidential to Projet Bessemer.

3.0 Steel Production and Markets

Statistics concerning Canadian steel production, capacity and shipments are found in Appendix 1. The flat rolled segment usually accounts for 50% of the steel shipments. The Ontario Steel Companies's capacities /2,3/ are shown in Table 1.

TABLE 1 - ONTARIO STEEL CAPACITY

COMPANIES	CAPACITY X 10^6 TONNES/YEAR	% CONTINUOUS CAST
Integrated	12.26	69.0
Non-Integrated (Mini Mills)	2.14	91.6

The NNSC of strip is obviously aimed at the flat rolled market. In the case of the integrated companies there is a significant portion of their flat rolled production capacity that is still produced by the ingot casting method. It is speculated that of the 3,800,000 tonnes/yr remaining in ingot production, 3,000,000 tonnes/year (Appendix 2) could be shifted to NNSC of strip over the next 20 year should the new casting technology be proven.

The non-integrated companies on the other hand could adopt NNSC of strip to enter the 'Hot Rolled Sheet and Strip' market which currently involves 3,240,000 tonnes/yr of shipments. Over the next 20 years if NNSC becomes available, these companies could at least participate in the growth of this market. This growth is speculated to be about 1%/yr/4/ which would be about 700,000 tonnes/yr in 20 years. The possible participation in this flat rolled market would more likely be about 400,000 tonnes/yr by the non-integrated companies as shown in Appendix 2. The non-integrated companies are unlikely to invest in costly, complex cold rolling facilities so that they will primarily be interested in the 'Hot Rolled Sheet and Strip' market.

The growth in the overall hot and cold flat rolled market is very questionable. There are strong suggestions that the market is levelling off and in North America possibly declining. The 1% per year growth figure/4/ is mainly related to population growth.

The advent of near-net-shape casting of strip, then, will be aimed at replacing ingot production. The increased yield of product, say 12-16%, compared to ingot production would probably satisfy some of the flat rolled market growth in the integrated companies. The entry of the non-integrated companies into the hot rolled strip segment would be aimed at satisfying the potential growth of the market in the future.

The mini mills (non-integrated) employing NNSC would have a product cost advantage over the integrated mills depending on scrap price. The integrated mills would retain a quality advantage over the mini mills because of the use of virgin iron from ore in their processes.

Finally, it is suggested that the highly efficient slab casters in the integrated companies would not be replaced by NNS casters in the foreseeable future. These facilities are well developed and are supplying the high quality end of the flat rolled products market.

Speculation as to the load implications of NNSC therefore, will be based on the foregoing suggested technology shifts and market trends.

4.0 Steelmaking and Casting Power Requirements

In order to estimate the load implications of NNS Casting it was necessary to determine the electrical requirements of traditional steelmaking, casting and rolling processes as they relate to strip production. Appendix 3 contains raw data obtained from the IISI[**]/9/ and US Steel's Making, Shaping and Treating of Steel/10/. The data in the Argonne National Laboratory's report/11/ also provides background. From these sources an estimate of process power requirements were made. These estimates are shown in Table 2 and in more detail in Appendix 3.

TABLE 2 - ESTIMATED PROCESS POWER REQUIREMENTS

PROCESS	KWhrs/TONNE OF STRIP	
Integrated:	Ingot Slabbing	Slab Casting
- Steelmaking (includes Ironmaking)	243	243
- Slab Casting	n.a.	39
- Ingot Slabbing	43	n.a.
- Hot Strip Rolling	142	142
- Total Integrated Process Requirement	428	424
Non-Integrated:		
- Steelmaking (Electric Arc Furnace, etc)	n.a.	520
Near-Net-Shape Casting of Strip	n.a.	95

A refinement of the foregoing power requirements would require more extensive study and analysis but appears adequate for the purpose of this speculative study. The electrical requirements for hot rolled strip and sheet (424 KWhrs/Tonne) includes process components such as oxygen usage, sinter/pellet production, etc some of which are, in part, external to the integrated plants.

[**] International Iron and Steel Institute

The estimate of the power requirement for near-net-shape casting of strip is mainly speculative. It assumes that 4 NNS strands are required to replace one slab caster strand. The experimental data in the literature for casting speeds of twin roll casters are highly variable. Figure 4 is an estimate of caster output, the best that could be determined at this time. Again estimates of strip caster capacity will be improved when more pilot plant data becomes available.

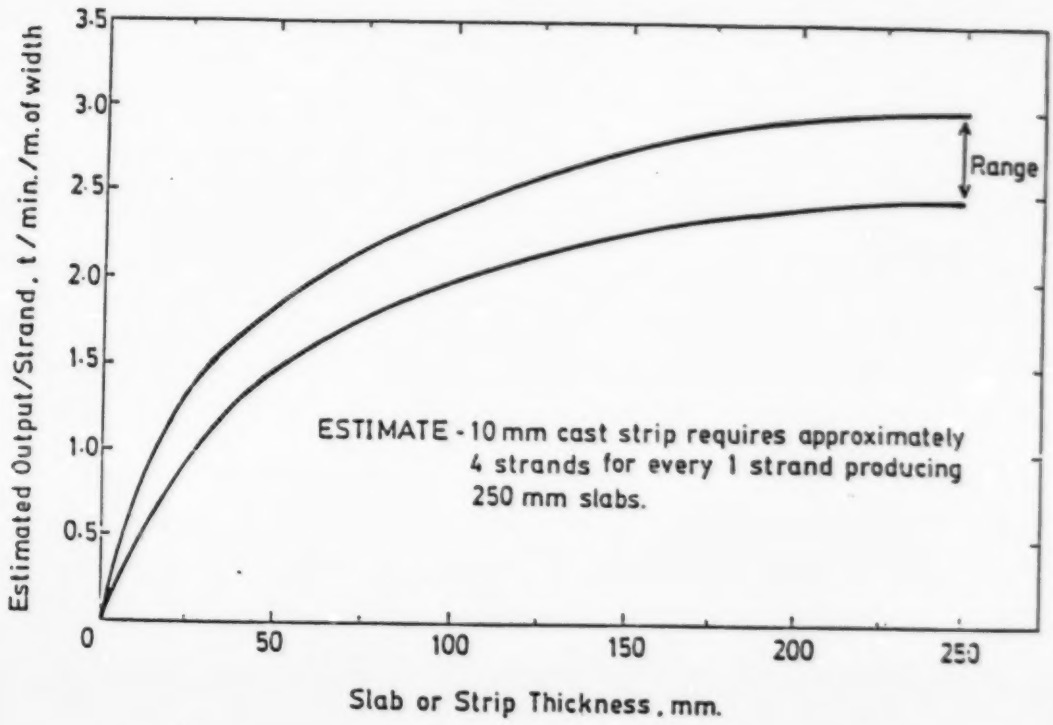

FIGURE 4 - CASTER OUTPUT ESTIMATE/5,6,7,8/

5.0 POWER IMPLICATIONS OF NEAR-NET-SHAPE CASTING OF STRIP

The ultimate developmental success of Near-Net-Shape Casting of strip will have significant power implications for the steel industry. Recently, the flat rolled segment of steel production has been undergoing a shift from the ingot production system to the slab caster route with resulting yield and power improvements. The adoption of NNSC would improve this situation further but would allow ingot production replacement with an even lower investment technology. Table 3 shows a possible speculative scenario. The accompanying power implications, for the replacement of 3,000,000 tonnes/year of the remaining ingot production by continuous casting (Slab or NNS) are also shown.

TABLE 3 - SPECULATIVE POWER IMPLICATIONS OF NNSC (COMPARING CASTING PROCESSES)

PROCESS	KWHrs/TONNE	MW*	CHANGE
Ingot Process 3,000,000 Tonnes	(43 + 142)	69.5(A)	
Slab Caster Process 3,000,000 Tonnes	(39 + 142)	68.0(B)	-1.5(A-B)
NNS Casting Process 3,000,000 Tonnes	95	35.5(C)	-34(A-C)
* Based on 8000 hrs/yr			

Table 3 indicates that NNSC technology would have a major effect on power requirements should it replace ingot production over the next 20 years. A saving of 34 MW would result. The increased yield resulting from such a shift may permit around 400,000 tonnes/year more product from the same capacity. This may result in increased product for cold rolling or an increase in saleable hot strip and sheet.

The success of NNSC of strip technology may permit the non-integrated mini mills of Ontario to enter the flat rolled product market. Such a response would also have a significant power implication. Table 4 presents a few possible scenarios assuming that various hot rolled sheet and strip tonnages were shifted to these mills from the integrated companies.

TABLE 4 - SPECULATIVE POWER IMPLICATIONS OF NNSC (MINI MILLS VS INTEGRATED MILLS)

MILL	FLAT ROLLED SHEET AND STRIP TONNES/YEAR	CASTING PROCESS	KWHrs/ TONNE	MW	CHANGE
Integrated	700,000	Slab Caster	424	37.1(a)	-
Integrated	700,000	NNSC	(243 + 95)	29.6(b)	-7.5(a-b)
Mini	700,000	NNSC	(520 + 95)	53.8(c)	+24.2(c-b) +16.7(c-a)
Integrated	400,000	Slab Caster	424	21.2(a)	-
Integrated	400,000	NNSC	(243 + 95)	16.9(b)	-4.3(a-b)
Mini	400,000	NNSC	(520 + 95)	30.7(c)	+13.8(c-b) +9.5(c-a)

The more likely case would be that the mini mills would enter the flat rolled market to the extent of 400,000 tonnes/yr as a participant in the market growth. This would increase power requirements by 13.8 MW over that required by the integrated mills to produce the same product or a total increase of 30.7 MW.

A wide variety of cases can be estimated using the power requirements given in Table 2. It is unlikely that the power implications will be the driving force in the shift to NNSC. It is likely that the Ontario Mini Mills would enter the flat rolled market by finding product niches just as they have done over the years in the shaped products market (bars, rods, wire, etc). The integrated companies have top class slab caster/hot strip mill operations at present. It is unlikely that these facilities would be replaced by near-net-shape casters for strip production.

6.0 Speculative Conclusions

1. NNS Casting of strip, if employed to replace ingot production, would reduce electrical load by 34 MW. This assumes 3,000,000 tonnes/yr of ingot production was replaced in the integrated companies.

2. The smaller economic size of a NNSC facility would permit non-integrated mini mills in Ontario to enter the flat rolled product market. This action would increase the electrical load by 30.7 MW for a 400,000 tonne/year penetration of the market over the next 20 years. The same production increase in the integrated mills would require 16.9 MW. The mini mills would show a net increase in load of 13.8 MW.

3. With the exception of the mini mills adopting NNSC of strip, all other scenarios for NNSC usage results in load reduction when compared to the existing ingot and slab caster routes for producing strip.

4. It is likely that NNSC would be used to replace ingot product and by the mini mills in order to find niches in the flat rolled market.

5. Mini mills employing NNSC of strip would have a cost advantage over integrated mills depending on scrap price. The integrated mills on the other hand would have a quality advantage because of the virgin iron source of their process.

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RAR/FJP:jz

REFERENCES

1. R. Reesor and F. Pearce - Report of Meeting at Bessemer Inc., October 17, 1990 (Nov. 1, 1990).

2. Energy, Mines and Resources, "Metallurgical Works of Canada 1986".

3. CSIRA/ARISC, Steel Industry Fact Book, 1988.

4. R. Reesor, et al, "Future Trends in the Processing of Scrap Steel", Ontario Hydro Research Division Report 89-29-K, April 1989.

5. Charles J. Labee, et al, "A Review of Quality Improvement Projects at Dofasco", Iron & Steel Engineer, September 1990.

6. Norman L. Samways, "Stelco Steel's Lake Erie Works at Nanticoke", Iron and Steel Engineer, September 1990.

7. L.P. Birat, "Continuous Casting for Tomorrow - Near Net Shape Casting", La Revue de Metallurgie, CIT, April 1989.

8. J.C. Agarwal, et al, "Economic Analysis of Thin Section Casting", Proceedings of an International Symposium on Casting of Near Net Shape Products, November 1988, Hawaii, The Metallurgical Society Inc.

9. IISI, Statistics on Energy in the Steel Industry (1990 Update) Committee on Statistics, Brussels, February 1990.

10. W.T. Lankford, et al, "The Making, Shaping and Treating of Steel", 10th Edition, United States Steel and the Association of Iron and Steel Engineers, 1985.

11. J.B. Darby Jr., et al, Energy and Material Flows in the Fabrications of Iron and Steel Semifinished Products, Argonne National Laboratory for US Dept of Energy, Contract W-31-109, August 1979.

APPENDIX 1

STEEL FACTS 1989

Published by
Canadian Steel Producers Association

The Algoma Steel Corporation, Limited
Co-Steel Lasco
Dofasco Inc.
Ipsco Inc.
Ivaco Inc.
Lake Ontario Steel Company
Manitoba Rolling Mills
QIT-Fer et Titane Inc.
Sammi Atlas Inc.
Sidbec-Dosco Inc.
Slater Industries Inc.
Stelco Inc.
Sydney Steel Corporation
Western Canada Steel Limited

Chairman: Peter Nixon
Vice-Chairman: Paul Ivanier
Managing Director: Daniel W. Romanko

50 O'Connor Street, Suite 1425, Ottawa, Ontario K1P 6L2 613-238-6049

TRADE STATISTICS (000 Net Tons)

	1983	1984	1985	1986	1987	1988	1989
SALES BY PRODUCERS (millions of dollars)	6,195.9	7,442.7	7,695.7	7,753.9	8,256.5	8,771.3	~~42 845~~
TOTAL SHIPMENTS* FROM CANADIAN PRODUCERS (i)	11,020	12,742	12,854	12,855	14,053	14,618	14,689
NET EXPORTS (ii)	2,960	3,401	3,236	3,843	4,254	3,904	4,356
NET IMPORTS (iii)	1,373	1,955	2,204	2,100	2,257	2,993	2,353
APPARENT DOMESTIC CONSUMPTION (i − ii + iii)	9,433	11,296	11,822	11,112	12,056	13,707	12,686
IMPORTS AS A % OF A.D.C.	14.6	17.3	18.6	18.9	18.7	21.8	18.5
IMPORTS FROM THE U.S.	587	583	563	501	688	1,007	1,087
U.S. IMPORTS AS A % OF A.D.C.	6.2	5.2	4.8	4.5	5.7	7.3	8.6
CAN EXPORTS TO U.S.	2,569	3,109	2,970	3,326	3,670	3,173	2,976
CAN EXPORTS TO U.S. AS A % OF U.S. A.D.C.	2.4	2.9	3.0	3.5	3.8	3.1	3.1

SOURCE: STATISTICS CANADA, CSPA

* SHIPMENTS OF STEEL MILL PRODUCTS INCLUDE ALL PRIMARY STEEL PRODUCTS, PIPE & TUBE, AND WIRE & WIRE PRODUCTS.
NET EXPORTS EXCLUDE EXPORTS FOR CONVERSION & RETURN. NET IMPORTS EXCLUDE IMPORTS BY PRODUCERS FOR FURTHER PROCESSING.

PRODUCTION STATISTICS (000 Net Tons)

	1983	1984	1985	1986	1987	1988	1989
RAW STEEL CAPACITY	23,519	23,519	23,519	19,815	19,815	19,815	19,815
RAW STEEL PRODUCTION	14,030	16,058	16,019	15,419	16,118	16,235[p]	16,901
CAPACITY UTILIZATION RATE	59.7	68.2	68.1	77.8	81.3	81.9[p]	85.3
CONTINUOUS CAST PRODUCTION	5,293	6,225	7,037	7,117	7,954	11,354[p]	12,964
% PRODUCTION CONTINUOUS CAST	37.7	38.8	43.9	46.2	49.3	69.9[p]	76.7
EMPLOYMENT (000 OF EMPLOYEES)	42	44	42	41	42	43.5	39.1
CAPITAL EXPENDITURES (millions of dollars)	166.2	189.9	439.4	843.2	757.1	534.0[p]	563.1[r]
PRODUCTION INPUTS:							
COAL CONSUMPTION	6,154	7,211	6,903	6,762	6,954	6,903	6,522
COAL IMPORTS FROM U.S.	6,042	7,211	6,845	6,494	6,635	6,886	6,522
IRON ORE CONSUMPTION	14,607	14,171	16,552	15,897	15,488	16,687[p]	17,234[p]
SCRAP CONSUMPTION	6,860	8,138	7,754	7,659	7,874	7,649	8,587

SOURCE: STATISTICS CANADA, ENERGY, MINES AND RESOURCES

p = Preliminary data
r = Revised data

"Steel — the Original Recyclable"

APPENDIX 2
ONTARIO STEEL COMPANIES/2,3/

INTEGRATED	CAPACITY X10^3 TONNES/YR	PRODUCT	% CONT. CAST	POTENTIAL NNSC STRIP
Algoma	3.5	Blooms. Blanks, Slabs, Shapes, Plate, Sheet, Structurals, Rail	72	Replace some Ingot Product Possibly strip cast - 250,000 tonnes
Dofasco	4.05	Plate, Sheet, Strip, Tinplate, Galvanize sheet, Electrical Steel, Ingots, etc	50	Replace some Ingot Production and new markets 20 yrs. Possibly strip cast - 2,000,000 tonnes potential, new market?
Stelco	4.71	Slabs, Blooms, Ingots, Plate Sheet, Strip, Rod and Bar, Galvanize Sheet, etc	84	Replace some ingot production and new market 20 years. Possibly strip cast - up to 800,000 tonnes.

Speculation

- Integrated, Potential for NNSC of Strip - 3,000,000 tonnes (max)/year. Ingot replacement.
  - However thin slab casting maybe more suitable for some plate production.
- Assume 1%/year average market increase for hot rolled sheet and strip would require 700,000 tonnes/year in 20 years.
  - Possibly satisfied by NNSC of strip.
- Existing strip mills and slab caster arrangement can be expanded particularly at Stelco's LEW.

NON INTEGRATED	CAPACITY X10^3 TONNES/YR	PRODUCT	% CONT. CAST	POTENTIAL NNSC STRIP
Slater	0.33	Billets, special merchant bars	100%	0
Courtice	0.25	Billets, Bars and shapes	100%	0
Atlas	0.30	Alloy Ingots, Billets	39%	0 - Flat rolled operation in Quebec
IVACO	0.36	Billets, Rods	100%	Electric furnaces could be upgraded to supply 200,000 tonnes/yr NNSC of strip.
LASCO	0.90	Billets, structurals (merchant and special Bar*) * Discontinued	100%	Electric furnace capacity for NNSC strip to supply 200,000 tonnes/yr. Thin slab caster may be preferred.

Speculation

- Non integrated companies potential to produce 400,000 tonnes/yr of the expanded market of 700,000 tonnes/year over next 20 years.

APPENDIX 3
POWER REQUIREMENTS - SUMMARY

Integrated Plants

Inputs

Coke, Pellets/Sinter, Blast Furnace	- 124 kwhrs/tonne of Iron
% of Steel Charge (73%)	- x.73
- Electricity from Iron	90.5 kwhrs/tonne of Steel
- Steelmaking, Ladle Metallurgy	
Oxygen	-113.0 kwhrs/tonne of Steel
	203.5 kwhrs/tonne of Steel
Liquid Steel Yield 90%	÷ .9
	226.1 kwhrs/tonne of Steel
Strip Yield 93%	÷ 93
	243.1 kwhrs/tonne of Strip
- Slab Casting - (36.0 kwhrs/Tonne of Slabs)	38.7 kwhrs/tonne of Strip
- Hot Strip Rolling-(132.0 kwhrs/Tonne ÷ Yield)	141.9 kwhrs/tonne of Strip
	423.7 kwhrs/tonne of Strip

Non Integrated Plants

- Electric Arc Furnace and Ladle Metallurgy	- 500 kwhrs/tonne of Cast Product
Oxygen	- 20 kwhrs/tonne of Cast Product
	520 kwhrs/tonne of Cast Product
- Near-Net-Shape Casting of Strip	95 kwhrs/tonne of Strip

POWER REQUIREMENTS - DATA

Source: IISI/9/ - Canada

152.9 kwhr/tonne - Steel Making and Casting.
217.6 kwhr/tonne - Rolling and Finishing.
49.6 kwhr/tonne - Oxygen used.

Steel Production: 11,781,000 tonnes/yr total.
9,812,000 tonnes/yr BOF 83.1%
1,989,000 tonnes/yr EAF 16.9%

Therefore - EAF requires 500 kwhr/tonne
+ 20 kwhr/tonne for O_2

- BOF requires 82 kwhr/tonne (Includes Casting)
+ 40 kwhr/tonne for O_2

Source: Making, Shaping and Treating of Steel/10/

Integrated Plants:		
Sinter and Pellets	44 kwhr/tonne	sinter/pellets
Coke	43 kwhr/tonne	coke
B.F.	28 kwhr/tonne	iron
B.O.F.	33 kwhr/tonne	steel
Ladle (est)	40 kwhr/tonne	steel (estimate)
O_2 (outside steel plant in some cases)	40 kwhr/tonne	steel (estimate)
Cont Casting	36 kwhr/tonne	steel
Hot Strip Rolling	132 kwhr/tonne	strip
Cold Rolled etc	137 kwhr/tonne	sheets, etc
Other facilities etc	50 kwhr/tonne	
Total Steel Plant	496 kwhr/tonne	steel (excluding O_2 and Ladle Metallurgy)

Source: IISI/9/

- Total kwhrs/tonne of steel including all operation, EAF's, BOF's etc - 561.2 kwhrs/tonne (excluding O_2).

- Broken down this gives roughly:
  - 436 kwhrs/tonne for integrated plants
  - 740 kwhrs/ tonne for nonintegrated

  These will vary depending on plant production.

- The 740 kwhrs/tonne for EAF (Nonintegrated) companies breaks down approx as follows.

  - 500+ kwhrs/tonne EAF and Ladle Metallurgy
  - 44 kwhrs/tonne Casting of Billets
  - 148 kwhrs/tonne Rolling of Billets

  excluding oxygen (20 kwhrs/tonne).

Strip Caster - Estimate

Estimate based on 4 NNSC strands for each slab caster strand.

Estimate	-	50 kwhrs/tonne - Casting
		10 kwhrs/tonne - Tundish Heating for Control
		20 kwhrs/tonne - Induction Heating Strip
		15 kwhrs/tonne - Rolling and Coiling
TOTAL		95 kwhrs/tonne of strip

Ingot Slabbing	-	40 kwhrs/tonne of slabs
	-	43 kwhrs/tonne of strip
Slab Casting	-	36 kwhrs/tonne of slabs
	-	39 kwhrs/tonne of strip

The power requirements are estimates and include components that could be considered, in part, separate from the actual steel plant. Power for oxygen supply, pellet and sinter production are among these. Refinement of this data could be made but would require considerably more study and analysis. This maybe useful if it was fully discussed with the steel companies along with their future casting plans.